



OCO-2 / MicroCarb Meeting, Caltech 27 January 2011

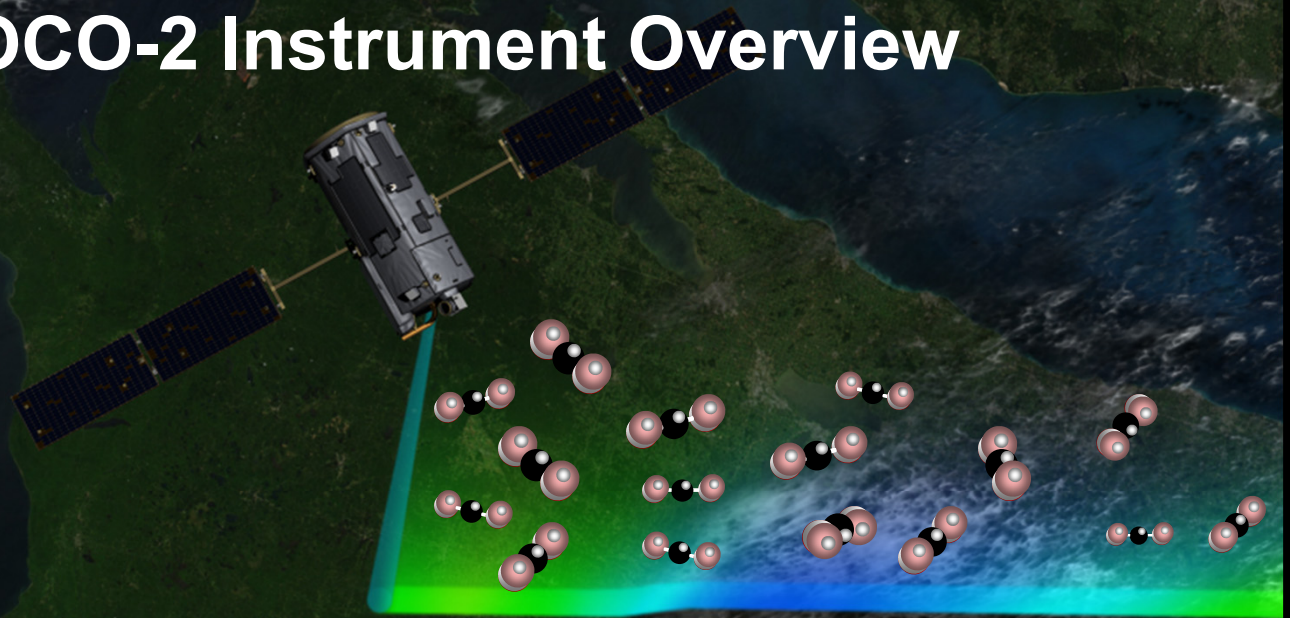
# Orbiting Carbon Observatory-2 (OCO-2): The OCO-2 Instrument Overview

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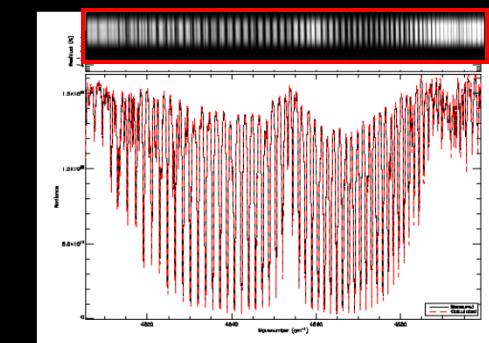
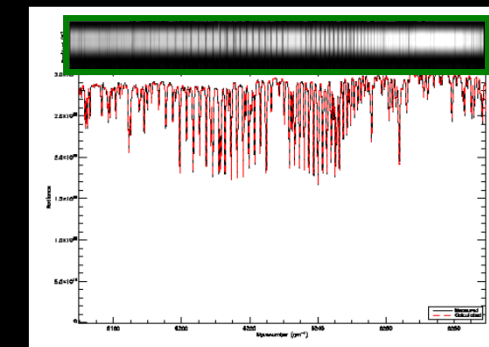
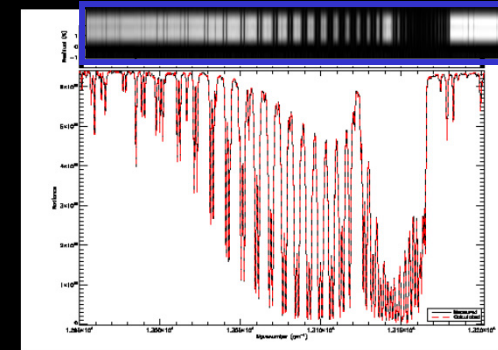
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## OCO-2 Measures 3 Spectral Regions

- O<sub>2</sub> A-band at 760 nm provides constraints on surface pressure, optical path length, and thin cloud/aerosol distribution
- Absorption in weak CO<sub>2</sub> band at 1610 nm is almost linearly dependent on CO<sub>2</sub> column
- Strong CO<sub>2</sub> band at 2060 nm
  - Somewhat less sensitive to the CO<sub>2</sub> column abundance
  - Very sensitive to clouds and aerosols
  - Also sensitive to water vapor column abundance and temperature profile
- Simultaneous retrievals in these three bands provide X<sub>CO<sub>2</sub></sub> estimates



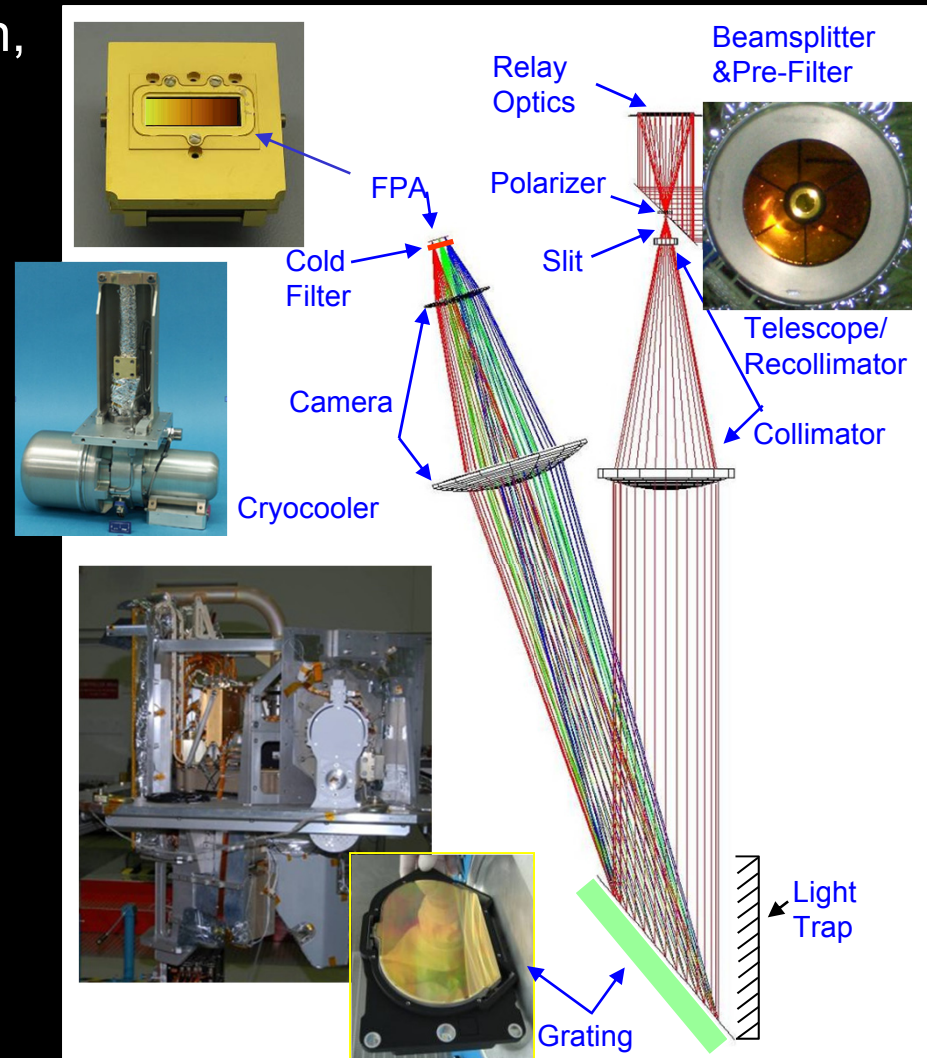


# The OCO-2 Instrument

- 3 co-bore-sighted, high resolution, imaging grating spectrometers
  - O<sub>2</sub> 0.765  $\mu\text{m}$  A-band
  - CO<sub>2</sub> 1.61  $\mu\text{m}$  band
  - CO<sub>2</sub> 2.06  $\mu\text{m}$  band
- Resolving Power > 20,000
- Optically fast: f/1.8 (high SNR)
- Swath: < 0.8° (10.6 km at nadir), resolved into up to 8 footprints
- Sampling rate: 3 Hz
- Mass: 140 kg, Power: ~105 W

## Changes from OCO

- New cryocooler
- Known anomalies addressed







## Same Spacecraft

The OCO-2 spacecraft

- Carries and points the instrument
  - Nadir, Glint, Target, and calibration observations
- Collects and transmits data to the NASA Ground Network
- Maintains its position in the A-Train

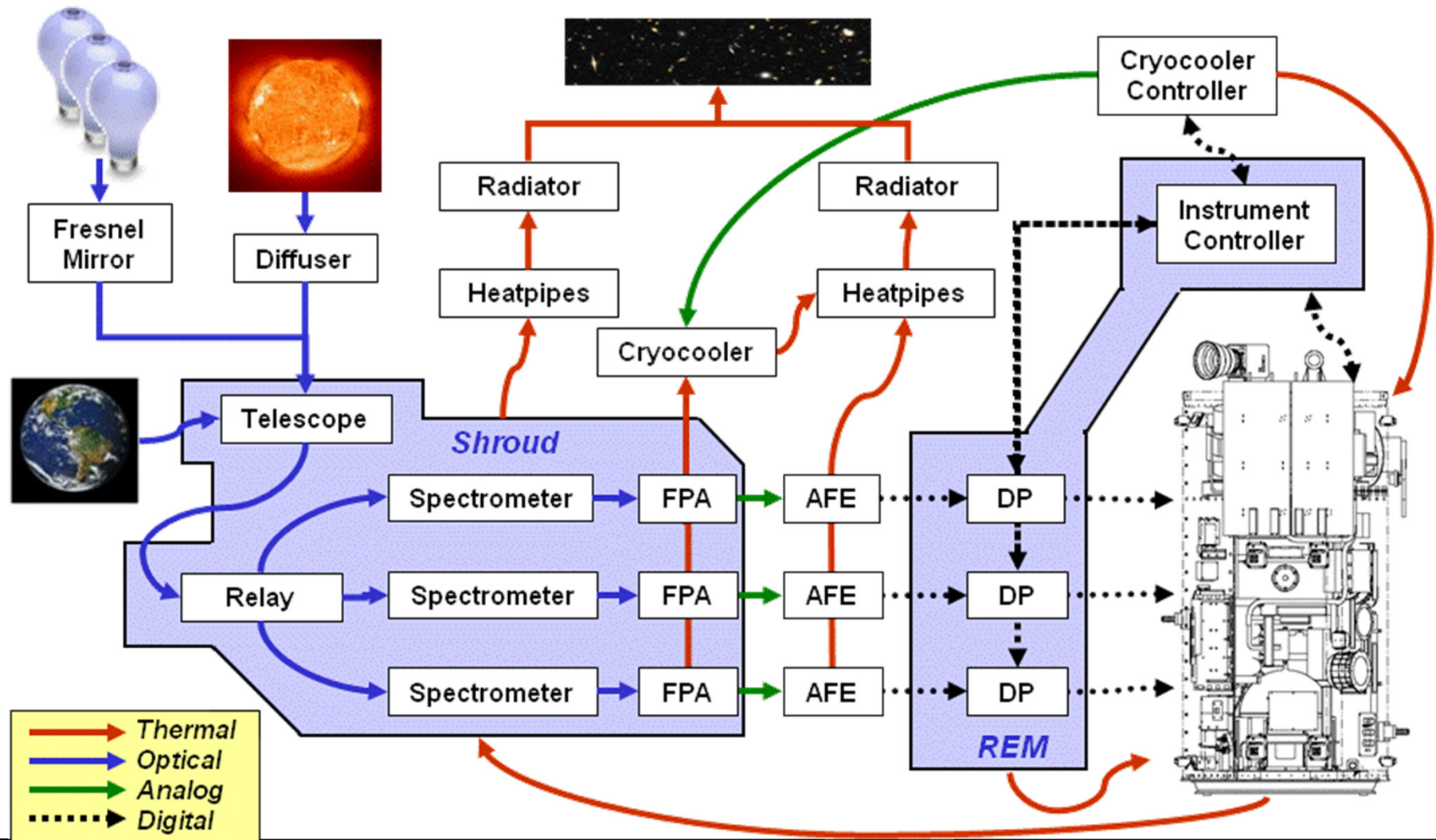
Orbital Sciences LEOStar-2 Bus

- 128 Gb of data storage
- 150 Mb/s X-band + 2 Mb/s S-band
- 4 Reaction wheels + 3 torque bars
- Articulated solar arrays
- Propulsion system for orbit maintenance
- Minimal changes to replace obsolete components



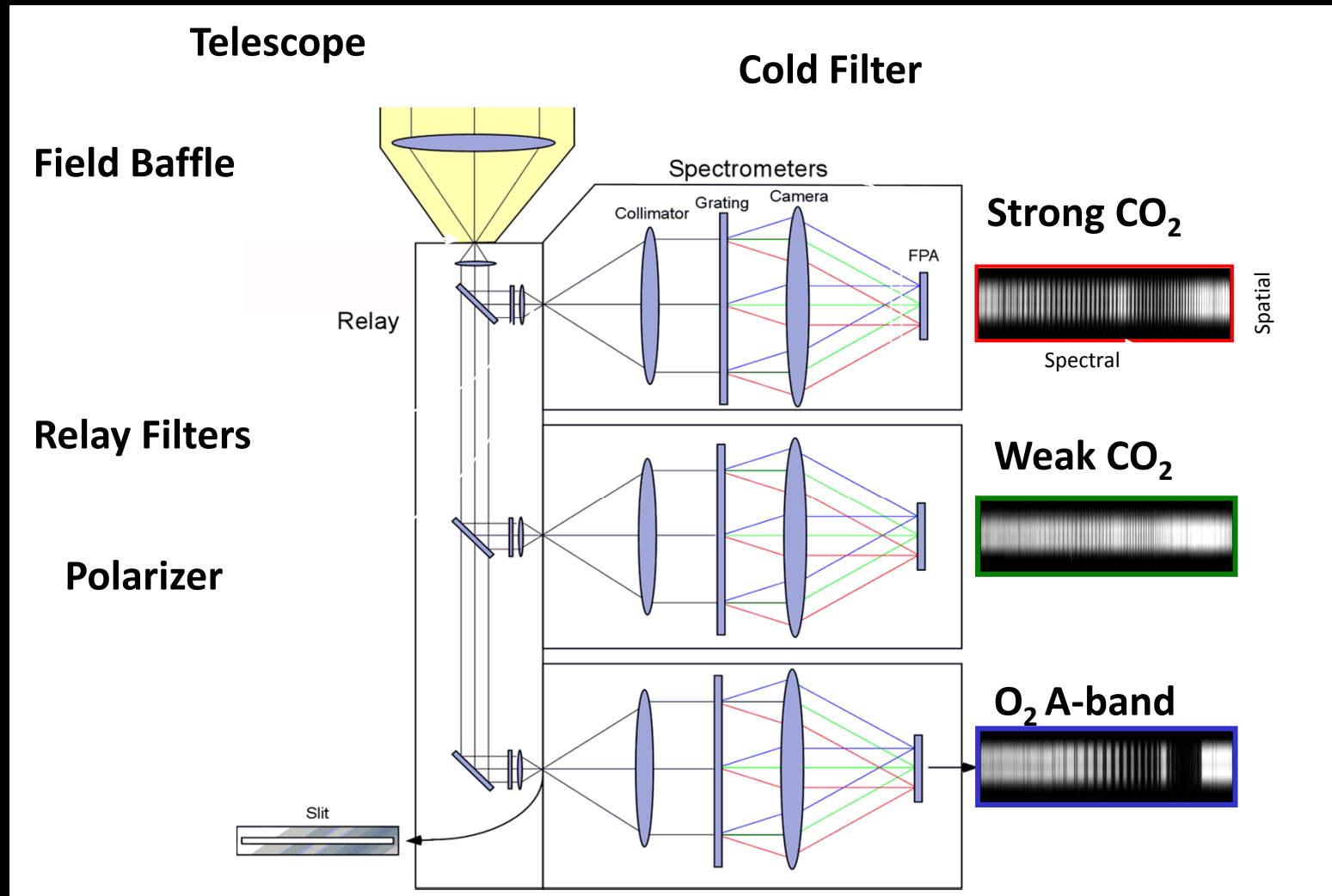


# Instrument Block Diagram



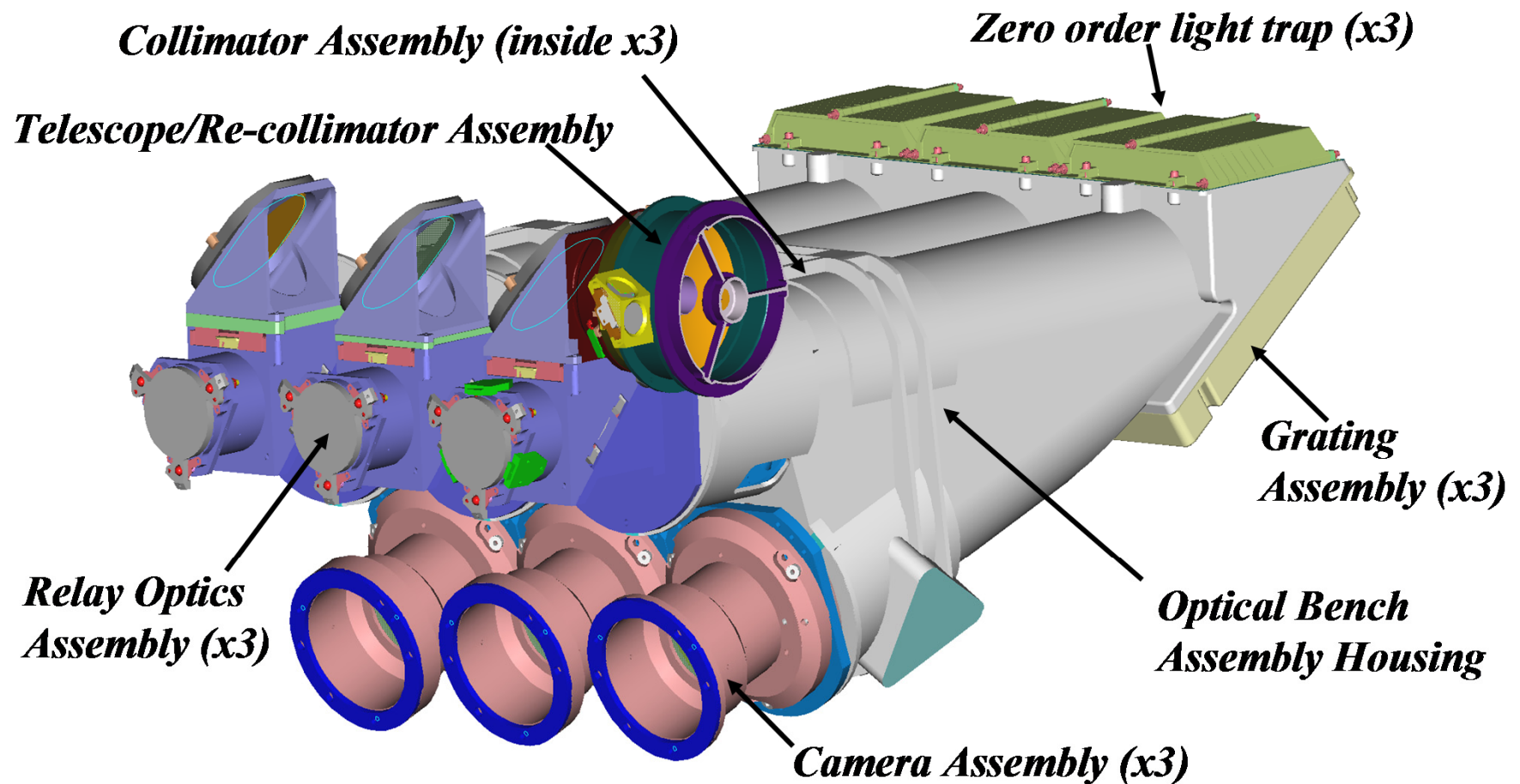


# Instrument Optical Block Diagram

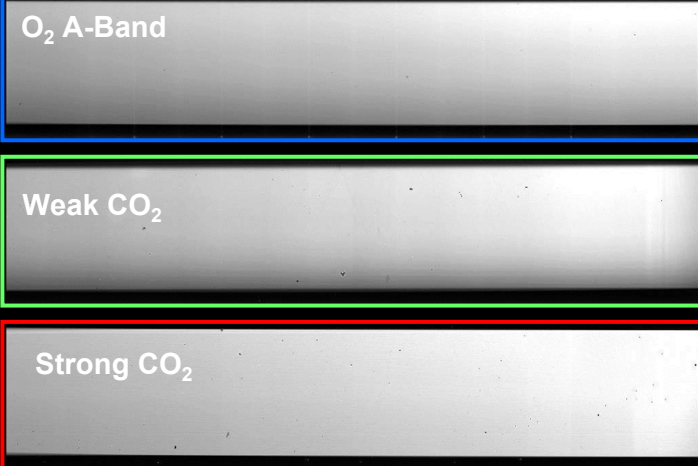
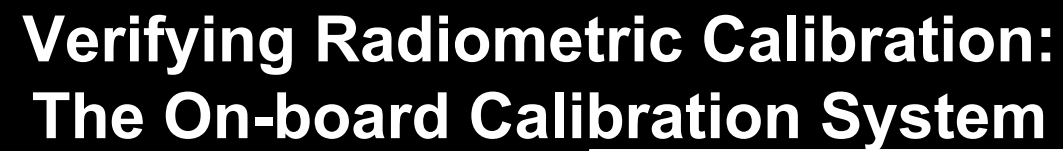




# OCO Optical Bench Assembly



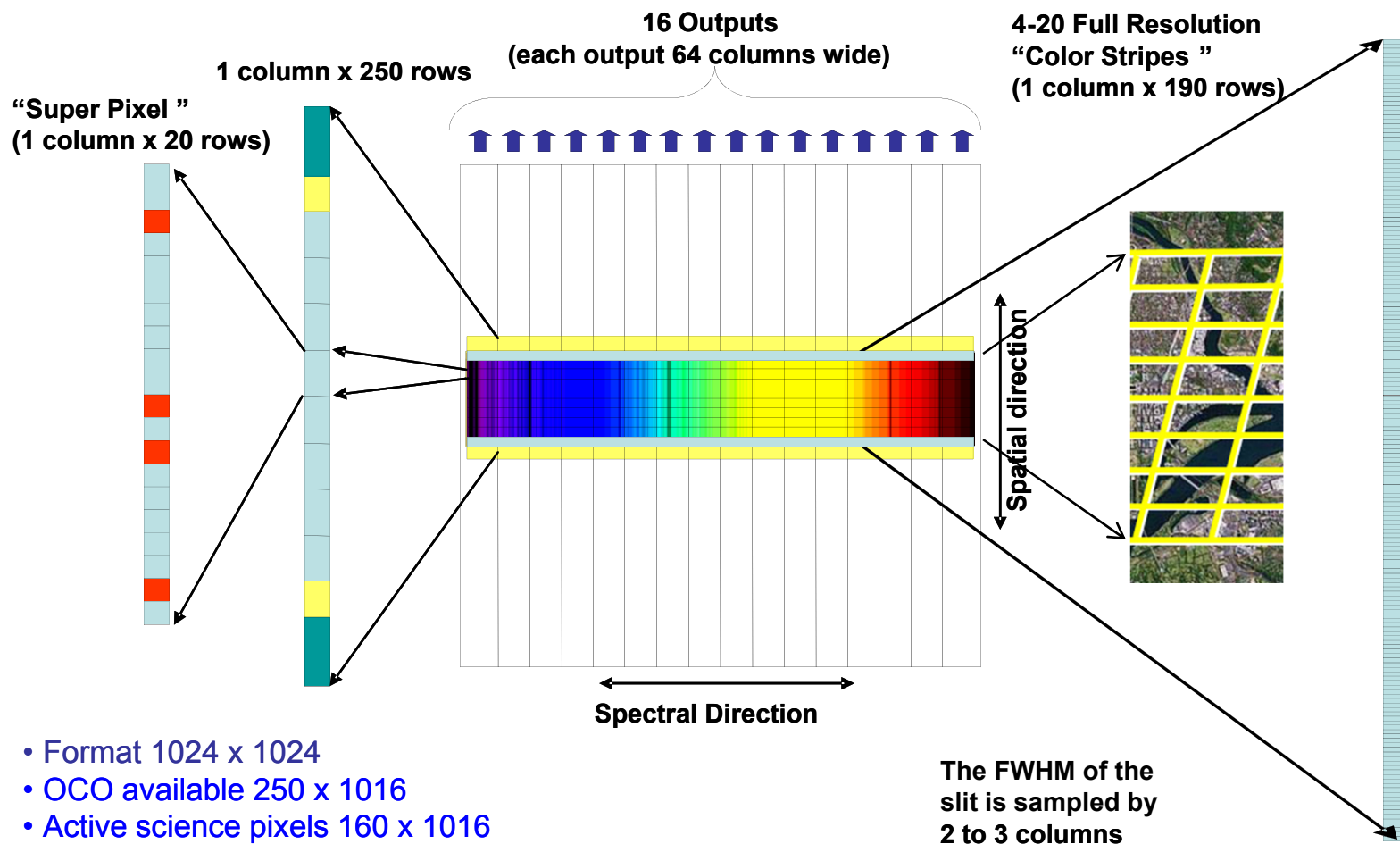








## Detector Readout



- Format 1024 x 1024
- OCO available 250 x 1016
- Active science pixels 160 x 1016



# Top Level Instrument Performance Requirements

Type of Requirement	O <sub>2</sub> A-Band	Weak CO <sub>2</sub>	Strong CO <sub>2</sub>
Radiometric*	SNR = 1 @ $1.9 \times 10^{17}$ SNR = 360 @ $2.2 \times 10^{21}$	SNR = 1 @ $9.0 \times 10^{16}$ SNR = 250 @ $2.2 \times 10^{21}$	SNR = 1 @ $1.0 \times 10^{17}$ SNR = 180 @ $2.2 \times 10^{21}$
Spectral	Range: 0.758 to 0.772 $\mu\text{m}$ Resolution: > 17,000:1 Sampling: > 2 pixels per slit	Range: 1.594 to 1.619 $\mu\text{m}$ Resolution: > 20,000:1 Sampling: > 2 pixels per slit	Range: 2.045 to 2.081 $\mu\text{m}$ Resolution: > 20,000:1 Sampling: > 2 pixels per slit
Spatial	Along Slit: $14.6 \pm 0.4$ mrad Cross Slit: $\leq 2$ mrad Alignment: $\leq 0.2$ mrad between bands		
Polarization	Alignment to Slit: < 8 degrees Knowledge: < 2.5 degrees		

\* Radiances are express in units of  
photons/m<sup>2</sup>/s/micron/steradian

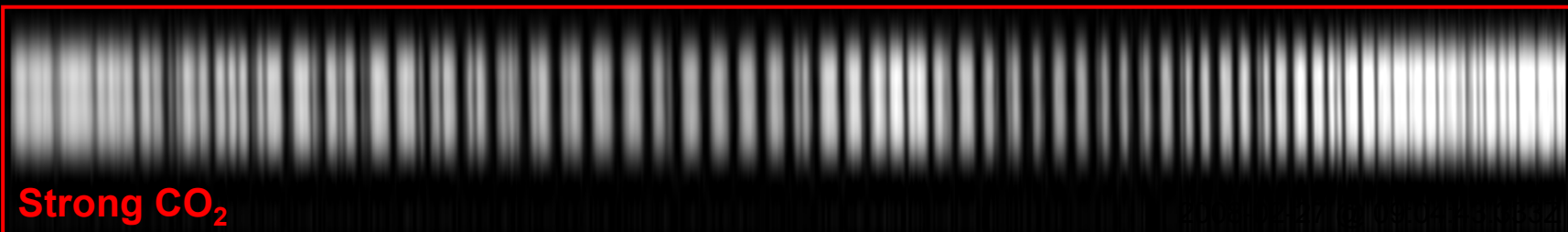
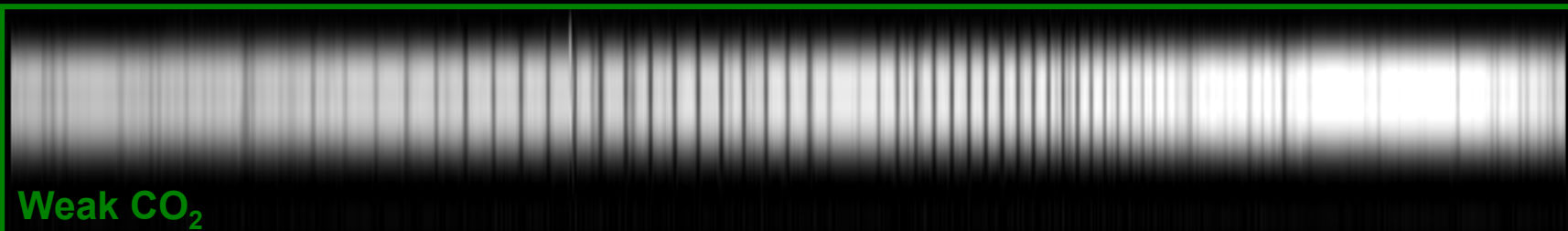
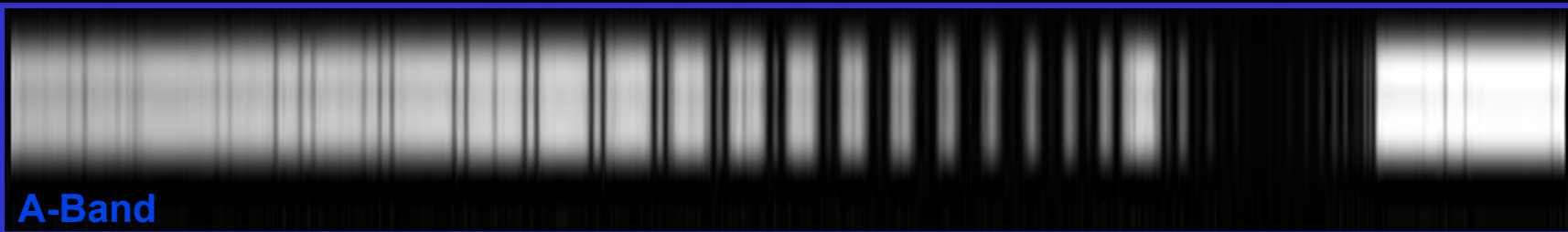


# Instrument is a Very Sensitive Imaging Spectrometer



## Single Frame of Data using the Moon

- High SNR (given low illumination levels)
- High spectral resolution (absorption bands are clearly visible)
- Imaging works (moon is  $\sim 0.5^\circ$  wide - just as expected)

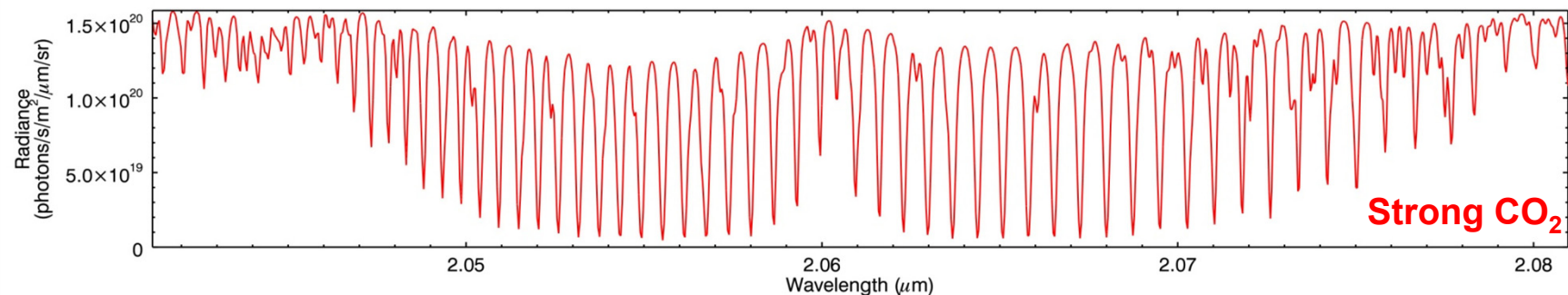
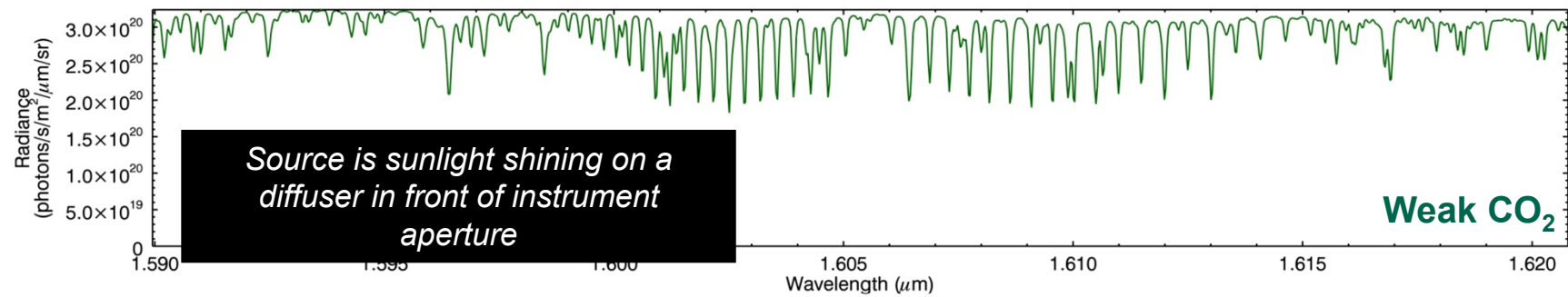
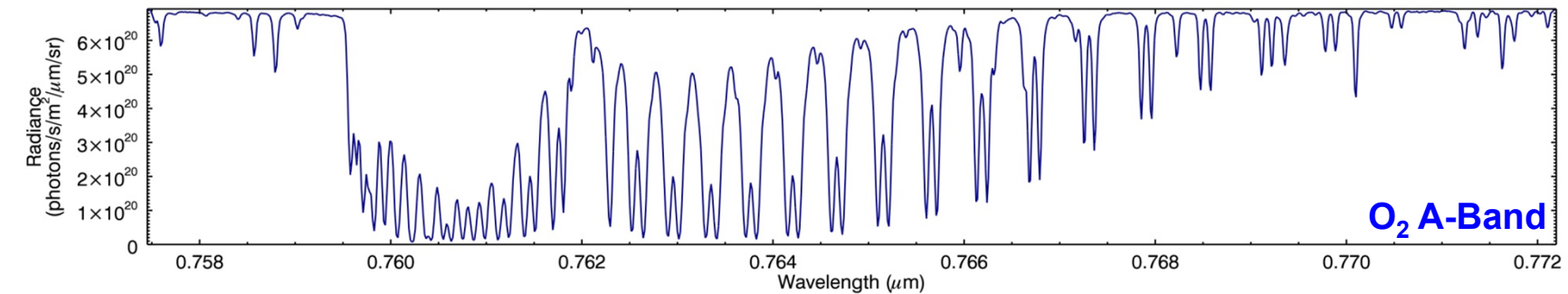






# Example of Single Frame of OCO Data

*High Signal to Noise / Low Stray light*





## Summary

The OCO-2 instrument was optimized for precise, bias-free measurements of the column-averaged dry air mole fraction,  $X_{CO_2}$

- 1.61 micron  $CO_2$  band most sensitive to  $CO_2$
- $O_2$  A-band and 2.06 micron  $CO_2$  band provide constraints on clouds, aerosols, and total dry air path
- High spectral resolution maximizes sensitivity
- Fast (f/1.8) optics and high throughput, combined with high QE, low noise detectors maximize signal-to-noise ratios
- Short exposure times (0.333 s) minimize footprint size, minimizing interference from clouds
- On-board calibration system facilitates maintenance of calibration after launch
- Use of spacecraft to point instrument precludes need for an additional pointing mechanism.